Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

# AVOCADO PESTS

WALTER EBELING
ROY J. PENCE

CALIFORNIA AGRICULTURAL
Experiment Station
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CIRCULAR 428

Larva of the omnivorous looper (see p. 20), showing the characteristic looping of the body when the insect is crawling. (× 2)

**AVOCADO PESTS . . .** like the one in the picture above . . . are on the rise in California. Others are less important than they used to be, but new pests are replacing them. Latest findings show that the best control program is to *spray as little as possible except where urgently needed.* You may destroy the natural balance between pests and their enemies, and also encourage new and more harmful pests. If you have to spray, use an acaricide (mite-killer) along with your insecticide.

**THIS CIRCULAR** presents up-to-date information on the status and control of pests on California avocados. It tells you how to identify them in the field, what new pests to watch, and what pests are of only minor importance. Consult the back cover for an alphabetical list of pests described in this circular. The CHECK LIST in the center of the circular summarizes control information on all pests of economic importance.

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**THE AUTHORS:**

Walter Ebeling is Associate Professor of Entomology and Entomologist in the Experiment Station, Los Angeles.

Roy J. Pence is Principal Laboratory Technician in the Department of Entomology, Los Angeles.

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# AVOCADO PESTS

WALTER EBELING ROY J. PENCE


Avocados are still a "young" crop in California. Commercial production was not seriously considered until 1910, and as late as 1924 the production for the year was only 130 tons in the state. As is usually the case when a fruit industry is newly established in a region, there followed a period of relative freedom from serious pests. The belief was often expressed in the early days of the industry in California that the avocado tree and its fruit are inherently immune to serious attack by insect pests.

Optimism like this was not justified by the experience in Mexico, Central America, and South America, where the avocado is a native fruit. Nor has it been justified by later experience in California. Many insects, both native and introduced, now attack the avocado tree and its fruit in the state. Some of these are annual pests in certain localities where the climate favors their development. Others are sporadic in their attacks, being serious only in certain localities and in certain years, when environmental factors combine to increase their populations to economically important levels.

Fortunately for the California grower, avocado pests in this state are in the main neither as serious nor as widespread as pests of most other subtropical fruit crops. Likewise they are more easily controlled. Natural enemies play an important role in keeping down pest populations (see page 4), and the distribution of some pests is sharply limited by climate.

Over a third of the original University of California bulletin on avocado pests (1935) was devoted to the latania scale, then known to be the most important pest of the avocado. Today, apparently through the effective work of natural enemies, this insect is a minor pest. Artificial control is no longer practiced. On the other hand, the greenhouse thrips—treated as a minor pest in 1935—and the six-spotted mite, which was not even mentioned, are now the most important pests of the avocado in California. Avocado pests, we see, have dramatically shifted in importance over the past few years. In addition, new pest species have come along; there is new biological information on several pests; above all, many new insecticides and acaricides (mite-killers) have come on the market, resulting in improved control measures for most avocado pests. This circular has been written to bring all this new information to the avocado grower.


Many avocado pests have natural enemies which control their populations. The latania scale and the long-tailed mealybug, once important pests of the avocado in California, have since been reduced to minor importance by the work of such enemies. Your pest control program must include ways and means of protecting them. *Do not spray unless urgently needed.* Untimely spraying can kill off natural enemies faster than the pests themselves, and destroy the natural balance of insect life which is still the most important control factor for the majority of avocado pests. Again, such spraying can introduce new, immune pests, whose own natural enemies may have been swept away with the earlier pests.

Apparently this is what has happened with the six-spotted mite—now a threatening pest on avocados. The use of insecticides has preserved these mites while destroying their natural enemies, and intensified their damage. Especially in the immediate coastal areas where the six-spotted mite threatens to become a serious pest, do not apply insecticides except where urgently needed, and always add an effective acaricide (mite-killer) for mite control.

*Ants* are known to interfere with the activities of the natural enemies of most pests on avocados, particularly of the six-spotted mite, the mealybug, and the soft scale. Ant control plays an important part in your pest control program.

### CAUTION!!

**Most insecticides are poisonous and should be handled with caution.** All labels on insecticide packages or containers should be read and if precautions are printed on these labels they should be followed carefully. Avoid body contact with insecticides and do not inhale dust or fumes from them. Liquid concentrates spilled on the skin or clothes are extremely dangerous. If this occurs, immediately remove clothing and bathe thoroughly with plenty of soap and water.

**Parathion is highly toxic to human beings.** Read instructions for use as printed on labels. A dust- and vapor-type respirator should be used to avoid inhaling the material. The use of parathion is still experimental in avocado pest control. Wherever possible, it should be applied by an experienced commercial operator.

### THE CENTER SECTION . . .

of this circular presents, in brief, a list of the avocado pests described, together with the recommended control measures. This Check Chart is printed on durable paper stock, and may be removed from the circular and tacked to a wall for quick and easy reference. For more detailed information about identification and control of each pest, read the individual descriptions in the circular.


## SIX-SPOTTED MITE

Although the six-spotted mite, *Eotetranychus sexmaculatus* (Riley), has been a pest of citrus in the immediate coastal areas of southern California for many years, it was not noticed on avocados until 1947. It never became abundant until the spring of 1950, and throughout that year it caused severe damage by defoliating trees in certain orchards in the Carlsbad and Encinitas areas of San Diego County. The six-spotted mite again caused some serious damage in 1951, but was not so abundant as during the previous year. It remains to be seen whether this mite will continue to be an important pest of avocados or whether in the future its appearance will be sporadic and closely dependent on favorable climatic conditions.

Considerable evidence shows that the six-spotted mite has become a pest on avocados as a result of the elimination of natural enemies caused by the widespread use of DDT in the control of the greenhouse thrips in recent years. It is likely that if insecticide treatments for other pests could be avoided, even at the risk of some loss from the pests, the six-spotted mite problem would be greatly alleviated, for the natural balance between the mites and their insect enemies would then not be destroyed.

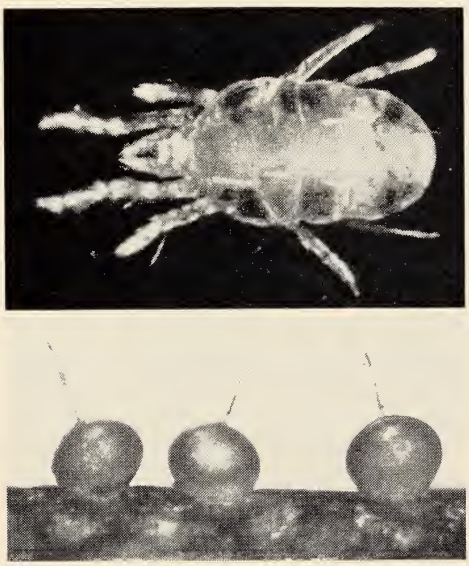


Fig. 1.—Six-spotted mite. Above, adult female; below, stalked eggs. (× 115)

**Appearance.** The adult mites (fig. 1) are about $\frac{1}{75}$ of an inch long, oval in shape, and so small that they can hardly be seen with the unaided eye. They are generally a lemon yellow in color, the majority having blackish spots usually grouped or coalesced into as many as six areas. On some there are fewer blackish areas while on others there may be none.

**Development.** The tiny, globular, pearly eggs, which bear a stalk at their apex (fig. 1), are found in areas where the mites are feeding and may be laid on the surface of the leaf or attached to the delicate webbing with which the mites cover such areas. In a period of 10 to 20 days the females may lay 25 to 40 eggs. These require from 5 days to 3 weeks to hatch, depending on temperature. From 8 to 12 days are required for the mites to reach maturity during the summer months.

**Injury.** The damage these mites cause to citrus leaves is well known. The mites occur in colonies on the lower surface of the leaf, causing a concavity with a corresponding bulge of the leaf on the upper surface, which becomes yellow. On avocado leaves the six-spotted mites also attack only the lower surface of the leaf, along the midrib and larger veins (fig. 2). The infested areas become brownish in color, but do not become depressed as they do on citrus leaves, for the avocado leaf is too rigid. The more severe infestations cause the leaves to drop. Of the principal avocado varieties, Anaheim,

Nabal, Wurtz, and Carlsbad appear to be the most severely attacked.

**Control.** The mites should be treated when the leaf symptoms of injury begin to appear and before serious injury to the trees has occurred. Following a continuous decrease throughout the late fall and winter months, the mites are likely to increase in numbers during the spring. Treatments with effective acaricides applied at that time have generally controlled the mites for an entire season.

Three new acaricides are recommended for use in the control of the six-spotted mite: Aramite, Ovotran, and Sulphenone. They are recommended as sprays in the following concentrations: Aramite 15 per cent wettable powder at 2 pounds, the 25 per cent wettable powder at 1¼ pounds (or the 25 per cent emulsifiable solution at 1¼ pints) to 100 gallons; Ovotran 50 per cent wettable powder at 1 pound (or the 25 per cent emulsifiable solution at 2 pints) to 100 gallons; and Sulphenone 40 per cent wettable powder at 2 pounds (or the 25 per cent emulsifiable solution at 3 pints) to 100 gallons. The sprays should be thoroughly applied, and since the six-spotted mites occur only on the under sides of the leaves, it is important to spray the inside of the tree. The addition of an effective spreader is recommended, for otherwise it is impossible to wet the under sides of the leaves.

A 3 per cent Aramite dust has shown promise in limited trials when applied with power dusters of adequate capacity.

Wettable sulfur has been used commercially at 5 pounds to 100 gallons with fair success, but even at this high dosage it is inferior to the above materials.

The systemic organic phosphate insecticide known as Systox has been used experimentally in limited trials. It shows considerable promise when applied as a spray or when painted on the trunks of the trees at the rate of from 2 to 4 ounces of the 32 per cent emulsifiable concentrate

Fig. 2.—Brownish discoloration along midrib and veins of the undersides of avocado leaves, caused by the six-spotted mite. (× 0.5)

per tree, depending on the size of the tree. When painted on the trunk, the insecticide reaches the mites through the sap stream as the pests feed on the foliage. It also controls the greenhouse thrips in this manner. *Possible toxic hazards of this insecticide have not been fully evaluated; consequently its use at present should be confined to nonbearing trees or nursery stock.*

The new acaricide known as Compound 338 appears to be very promising against the six-spotted mite in preliminary experiments.

**Ants** are known to interfere with the activity of the natural enemies of mites, and ant control is recommended to aid in combating the six-spotted mite as well as the majority of other mite and insect species that are pests of avocados. The writers have had excellent results in ant control with a slurry of about 2 pounds of 50 per cent wettable chlordane powder to a gallon of water. This is applied to the trunks of the avocado trees, by means of a paint brush, in a band 4 inches wide. Ants must crawl over the chlordane in climbing the tree. However, if any of the lower limbs should touch the ground they either must be cut back or chlordane dust or spray must be applied at the point of contact with the ground. When the chlordane is applied in this way the ground irrigation sprinklers do not remove enough residue to reduce its effectiveness. *Observe precautions in the use of this material as indicated on page 4.*

## AVOCADO BROWN MITE

The avocado brown mite, *Paratetranychus coiti* McGregor, has been known to infest avocado trees in California for over two decades. Severe infestations may cause considerable defoliation. Occasionally, treatments are applied for the control of this mite.

**Appearance.** The avocado brown mite (fig. 3) is approximately the same as the six-spotted mite in size and shape, but is predominantly dark brown.

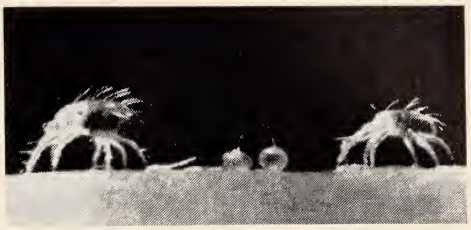


Fig. 3.—Avocado brown mite. Left, adult female; center, stalked eggs; right, adult male. (× 29)

The webs are very delicate and may be invisible to the unaided eye, but examination of the upper leaf surface, with binoculars, will reveal considerable webbing, especially in the region of the midrib and over depressed areas. However, the webbing may be described as light in comparison with many spider mite species.

**Development.** The globular, amber-colored eggs (fig. 3) are stalked, like those of the six-spotted mite. They are laid first along the midrib but are later found distributed quite generally over the upper leaf surface. There may be two complete generations per month during the warmer periods of the year.

**Injury.** The mites are found on the upper sides of the leaves, at first congregated along the midrib, then along the smaller veins, or even entirely over the upper leaf surfaces in heavy infestations. The area along the midrib, and finally along the smaller veins, becomes brownish. In addition to the typical discoloration of the leaf, an avocado brown mite infestation is characterized by the myriads of whitish eggs and cast skins of the mites.

The destruction of chlorophyll no doubt reduces the value of the leaf to the tree. The green color returns if the mites are controlled, otherwise the leaf may drop if the mite population is very heavy.

It appears that this mite does not cause so much damage as might be expected when compared with the severe defoliation that can occur from much lighter infestations of the six-spotted mite. Some

growers in recent years have discontinued treatments for the avocado brown mite, even when it is present in considerable numbers, yet have seldom suffered economically important damage. Severe infestations, if present, are likely to occur only on trees in the border rows, presumably because the road dust accumulating on such trees is detrimental to natural enemies.

**Control.** The avocado brown mite is especially well controlled with sulfur, which is most economically applied as a dust. From ¼ to ½ pound of sulfur per tree is sufficient, depending on the size of the tree. Sulfur is only effective at temperatures above 70° F. Wettable sulfur at 2 pounds to 100 gallons is also used in brown mite control, or may be added to DDT used for the control of the greenhouse thrips. However, severe injury to the foliage and fruit may result in areas removed from the coast, such as Vista, at temperatures around 85° F.

## PLATANI MITE

During the past year a species of mite not previously recorded from avocado has been found on this host in San Diego, Ventura, and Santa Barbara counties. This mite is known as *Paratetranychus platani* McGregor. It is believed to be generally distributed on avocado trees throughout southern California. It also feeds on camphor, cotoneaster, cypress, eucalyptus, loquat, oak, pyracantha, sycamore, toyon, walnut, and willow. It is reported to be a serious pest of loquats in the San Francisco Bay area.

Fig. 4.—Pallid mite, Tydeus californicus (Banks), on the underside of an avocado leaf.

The platani mite feeds on the upper surfaces of avocado leaves and causes a brownish discoloration similar to that which is caused by the related avocado brown mite. This mite appears to be under satisfactory natural control at present, but should be regarded as a potential pest of the avocado.

## PALLID MITE

A species of mite, *Tydeus californicus* (Banks), has become rather extensively distributed on the avocado in recent years and is very abundant in some orchards. It occurs on the undersides of leaves, is whitish in color, slightly larger than the six-spotted mite, but has no black spots (fig. 4). Nevertheless, it is commonly mistaken for the six-spotted mite.

*T. californicus* is closely related to some species that are predators, but on avocado it has never been seen feeding on other mites or insects. Large numbers may be seen on leaves where there is nothing on which the mites could feed but the leaves themselves. No injurious leaf symptoms have been associated with this species, however, and experiments are now under way to determine whether the mites may have an insidious effect that could, over an extended period, gradually devitalize the tree without producing acute symptoms.

## BROAD MITE

This species, known as *Hemitarsenemus latus* (Banks), has been found attacking the tips of avocado seedlings in greenhouses, causing a characteristic crinkling and dwarfing of terminal foli-

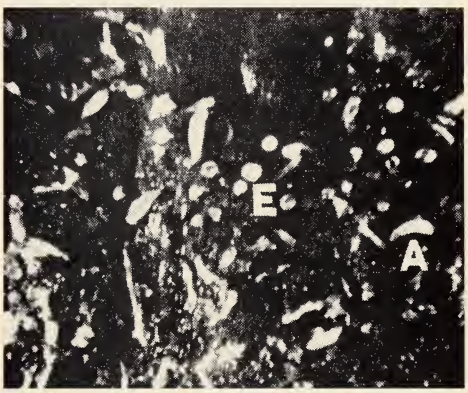
age (fig. 5). Since avocado seedlings are ordinarily grown outdoors, this pest is not of general interest. Where seedlings are forced in greenhouses or where tip grafting is practiced, however, the symptoms of injury caused by this mite should be recognized. The broad mite may be controlled by repeated applications of sulfur dust.

## AVOCADO BUD MITE

These tiny mites, known as *Epitimerus myersi* Keifer, are even smaller than the preceding species and are invisible to the unaided eye. They are narrow and elongate and have only two pairs of legs as compared with the four pairs of the spider mites. They were first found on avocado in 1938. They appear to be quite widely distributed throughout the avocado growing area in California. The mites can be most readily found under the "buttons" of the fruits, and the writers have found as many as 186 in one such location (fig. 6). Despite their abundance at times, there is no evidence as yet that the mites cause appreciable injury of any kind.

## SNOWY TREE CRICKET

The green twigs of avocado trees are occasionally injured by the egg laying punctures (fig. 7) of the snowy tree cricket, *Oecanthus niveus* (De Geer). If the infestation is sufficiently severe some small twigs may be killed, but apparently no damage of economic importance has ever been observed on avocados. Among the other subtropical fruit crops, these insects have been found attacking cherimoya trees, and on persimmon trees they are known to be a carrier of a disease causing fungus that attacks the twigs.



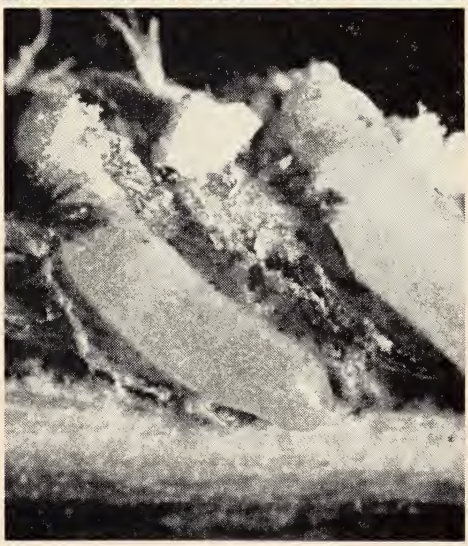



Fig. 5.—Top: left, normal foliage of an avocado terminal; right, dwarfed and crinkled foliage of a terminal infested with broad mite. (× 0.55). **Fig. 6.**—Center: a colony of avocado bud mites under the "button" of an avocado. A, adults; E, eggs. (× 13.2). **Fig. 7.**—Bottom: eggs of the snowy tree cricket embedded in an avocado twig. (× 35)

## GREENHOUSE THRIPS

The greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), is widely distributed in tropical and subtropical regions and, in greenhouses, in temperate regions. In California and Florida it occurs outdoors on avocado, citrus, and many other hosts. In California the greenhouse thrips had been known to occur on avocados for many years, but was considered as one of the minor pests. Within the last decade, however, it has rapidly increased the severity of its attacks. Except during years following winters of exceptionally low temperatures, the greenhouse thrips populations may become so great, if uncontrolled, that from 50 to 90 per cent of the fruit in some orchards may become scarred, with a consequent loss in market value.

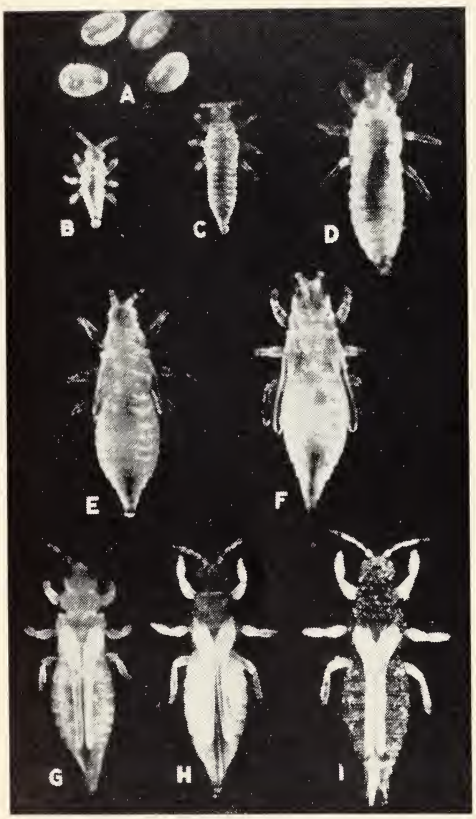



Fig. 8.—Photomicrographs of greenhouse thrips. A, eggs in late stages of development; B, newly emerged 1st instar nymph; C, fully developed 1st instar nymph; D, 2nd instar nymph; E, prepupa; F, pupa; G, newly emerged adult; H, adult 1 hour old; I, adult several days old.

**Hosts and varietal susceptibility.** Other subtropical fruits attacked are citrus, grape, mango, sapote, cherimoya, and guava. Among ornamental plants, the carissa, rose, arbutus, viburnum, statice, mandevilla, fuchsia, eugenia, myrtle, azalea, euonymus, hibbertia, cypress, eucalyptus, and mesembryanthemum are especially severely attacked. Infested ornamentals growing near avocado plantings should be removed so that they will not be a source of infestation. The same may be said of bush berries, often found in and near avocado orchards. Among the avocado varieties, the Mexican seedlings, such as Northrop and Puebla, are especially severely attacked. Although they are of no commercial value, they may serve as sources of infestation for commercial varieties. They should either be removed or treated at the first sign of thrips.

Among the least susceptible varieties are the Anaheim and Nabal. The Fuerte and Dickinson are also relatively resistant when compared with such highly susceptible varieties as Itzamna, Hass, Carlsbad, Benik, Queen, Panchoy, Milly-C and Wurtz.

**Appearance.** The eggs (fig. 8, *A*) are about $\frac{1}{75}$ inch long when laid, and are white and kidney-shaped. They are inserted singly into the leaf tissue beneath the epidermis of either the upper or lower leaf surface or into the fruit (fig. 9). They continue to increase in size and become considerably swollen and distorted near the end of the incubation period. This gradual increase in size causes a corresponding swelling of the leaf cuticle, and the "egg blisters" (fig. 10) denoting the locations of the eggs are then readily seen with the aid of a hand lens, although when the eggs are first laid there is no outward evidence of their locations.

The newly hatched nymph (fig. 8, *B*) has a small, tapered abdomen which dis-

tends after feeding and becomes slightly yellowish. Before molting, the first-instar nymph attains the length of about 1/30 inch (fig. 8, *C*). It is yellowish white in color and has red eyes, as do all the immature stages. The second-instar nymph (fig. 8, *D*) varies from a length of 1/30 inch after the first molt to about 1/25 inch just before pupation. It is yellowish white, like older first-instar nymphs.

A peculiar characteristic of the nymphs is their habit of carrying a globule of liquid feces on the tip of the last abdominal segment, where it is supported by six hairs (shown in fig. 10). This fecal liquid is first reddish, then becomes black. The globule of liquid increases in size until it falls off, then another globule begins to form. These are the "specks" that dot infested fruit and foliage.

**Pupal stages.** The prepupa (fig. 8, *E*) is a millimeter or more in length and yellowish white. The pupa, slightly larger, is also at first yellowish white, becoming more yellowish with age (fig. 8, *F*).

**Adult.** Upon emerging from the pupal skin, the adult is whitish throughout (fig. 8, *G*). The wing tassels are folded forward, but soon unfold into their functional position. Within an hour the head and thorax become black (fig. 8, *H*) as does the abdomen a few hours later. Thus the adult female, a few hours after emergence, is black with whitish legs, antennae, and wings (fig. 8, *I*). The length of the body is about 1/20 inch. Males are practically unknown, and the female reproduces without fertilization.

**Development.** An individual thrips may lay as many as 60 eggs. In the laboratory, the average life cycle from egg to the egg laying stage was found to be 46.1 days. In the field, nearly five generations of greenhouse thrips were found in one year in observations made on an avocado tree on the University of California campus at Los Angeles. Nearly six generations were found at Carlsbad, California. In Carlsbad, all active stages of the thrips were found on the foliage throughout the winter of 1946–47 whereas at the University, where temperatures are somewhat lower, the thrips survived the coldest period of the winter in the egg stage only, and newly hatched nymphs were not found until the middle of February (fig. 11).

Fig. 9.—Cross section of greenhouse thrips egg inserted beneath epidermis of an avocado leaf in the typical manner. (× 109)

Avocado trees lose much of their foliage during the flowering season, and some varieties are nearly bare for a brief period in the spring. Almost the entire

Fig. 10.—Larvae, prepupa, and adults of greenhouse thrips on carissa. Note egg blisters (arrows), some with exit holes of egg parasites. (× 7.5)

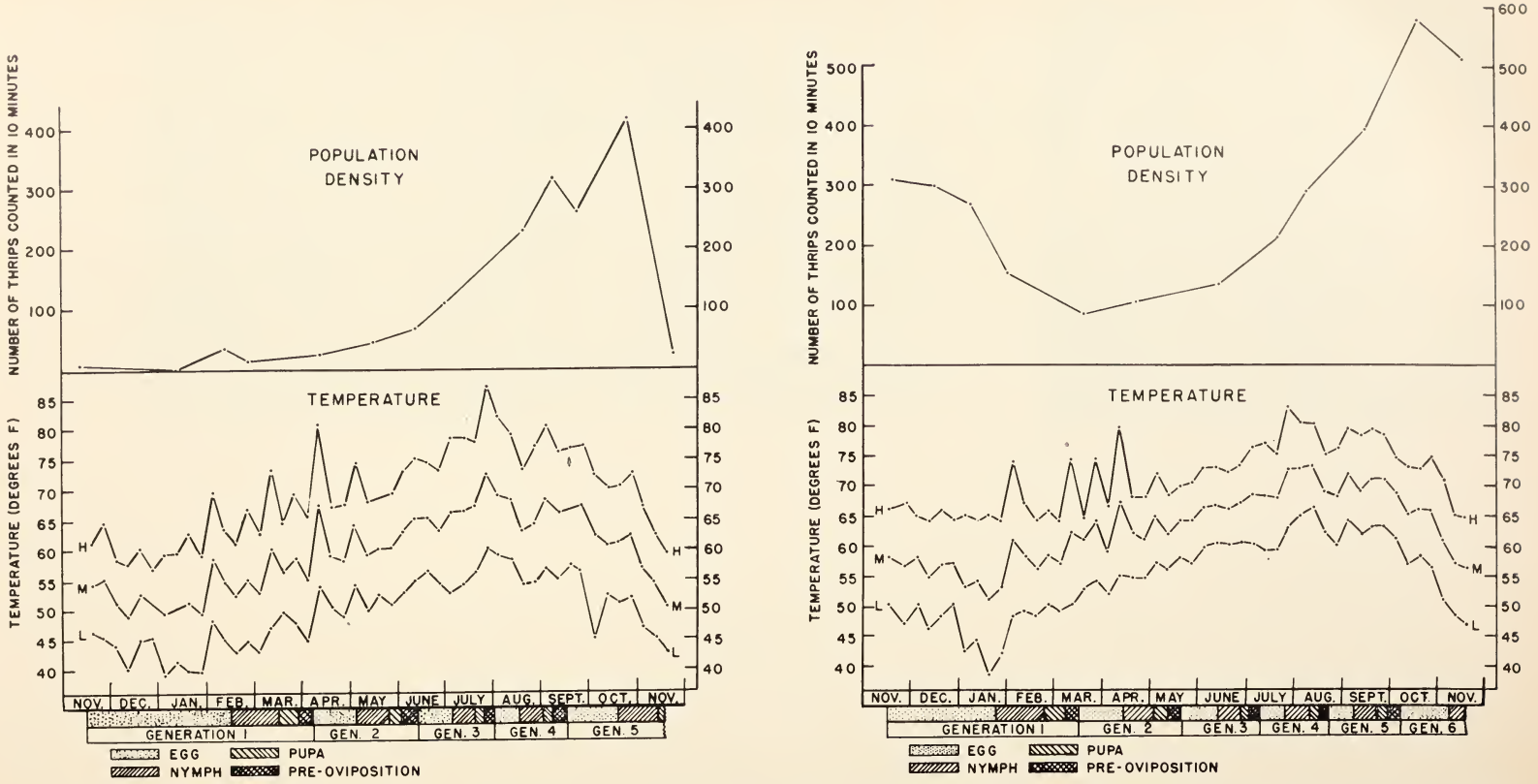



Fig. 11.—Seasonal life history and seasonal fluctuation in population density of the greenhouse thrips at U.C.L.A. (left) and Carlsbad (right). The population density curves are based on the number of thrips found in 10 minutes on the trees on which the life history studies were made, on various dates throughtout the year. The polygons below show the duration of the life stages at various periods of the year, starting with eggs laid in November, 1946.

overwintering thrips population is annually destroyed by this severe defoliation, and usually the thrips do not reappear in numbers sufficient to cause injury until some time during the fall.

**Injury.** Thrips injury on the foliage begins to show usually sometime in June, in the form of small, whitish, silvery, or ashy-gray patches on the upper leaf surfaces where the thrips are found in greatest numbers. These discolorations are caused by the puncturing of the epidermal cells of the leaf and the extraction of the chlorophyll. The greatest numbers of thrips are found on the inside of the tree, to the north, away from direct sun.

The whitish discoloration of foliage and fruit (fig. 12, top) caused by the earlier infestations changes to a brownish discoloration later in the season. The epidermis of both leaves and fruits becomes thickened, hardened, and cracked (fig. 12, bottom), and the characteristic black specks of thrips excrement become noticeable on the infested parts. It is not likely that much damage is done to the tree by extraction of sap and chlorophyll. The commercial damage consists mainly of the reduced value of the fruit resulting from cullage of the discolored, cracked, and scarred fruit. The loss may amount to 50 to 90 per cent of the value of the crop in some years and with some of the more susceptible varieties.

**Control.** The present recommendation for the control of greenhouse thrips is to spray with 1½ to 2 pounds of 50 per cent DDT wettable powder to 100 gallons, plus an effective spreader or wetting agent. Since DDT increases the mite infestation, a suitable acaricide should be added to the spray. Wettable sulfur at 2 pounds to 100 gallons has been used in addition to the DDT in past years, but one instance of severe damage to foliage and fruits was observed when such a spray was applied at Vista while the temperature was 84° F. One pound of wettable sulfur to 100 gallons has been found to be effective in controlling avocado brown mite, and is recommended for use with DDT in the inland areas. In coastal areas where the six-spotted mite is present, it is advisable to add an acaricide to the DDT spray.

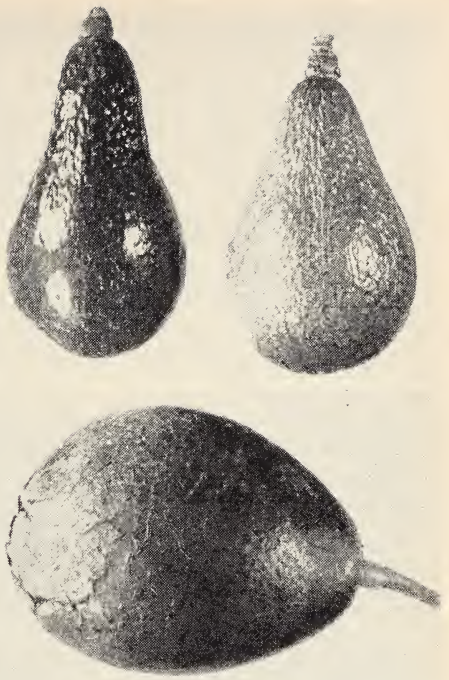


Fig. 12.—Above: left, uninfested Itzamna avocado; right, same variety turned white by thrips feeding, but not yet brownish and cracked. Below: Fuerte avocado with brown, leathery, cracked peel caused by prolonged greenhouse thrips infestation.

Avocado trees may grow close to the ground and spread out and interlace their branches. This growth habit prevents the use of motorized equipment within an orchard of mature trees. If power sprayers are to be used, from 200 to as many as 1,500 feet of hose must be pulled into the orchard from the road or from such "picking drives" as may be provided to facilitate the hauling of the fruit from the orchard. Obviously, spray towers are not used, but this does not appear seriously to reduce the effectiveness of the treatment, for thrips avoid the outer foliage at the tops of the trees,

seeking the cooler foliage farther removed from the direct rays of the sun.

The DDT spray is applied at the period when the thrips are beginning to appear in appreciable numbers. This period will vary from year to year, depending on the severity of the preceding winter, and will also vary in different orchards. Generally, however, the sprays are applied from the first of August through October. Both experimental work and commercial experience have shown that the most severe infestations may be controlled for at least a year by a properly applied DDT spray.

Eight insecticides have been found to be more toxic than DDT to the greenhouse thrips, namely, dieldrin, lindane, toxaphene, dilan, parathion, malathon, TEPP (tetraethyl pyrophosphate), and Systox. Of these, dieldrin shows particular promise. A 1 per cent dieldrin dust at ½ to 1 pound per tree gives a high initial kill as well as prolonged residual effect. This effect is particularly important in the control of greenhouse thrips because of the long period required for the eggs to hatch (see fig. 11), during which they are protected from insecticides in the epidermal tissue of the leaf. However, dieldrin has not yet been released for use on avocados pending further studies on the public health aspects of the problem.

Dilan wettable powder has been found to have far more prolonged residual effectiveness than DDT. Likewise, malathon 25 per cent wettable powder at 2 pounds to 100 gallons shows promise against greenhouse thrips. It has the added advantage of being effective against mites, and is one of the safest of the insecticides for humans to use.

Among the organic phosphates that have been used experimentally, parathion and Systox are very effective in controlling greenhouse thrips. The systemic insecticide Systox is effective as a spray, but may also be painted on the trunk, thus reaching the thrips through the sap stream as the pests feed on the foliage. Two to 4 ounces of the 32 per cent emulsifiable concentrate, depending on the size of the tree, have been found to result in a complete kill of active stages as well as to provide prolonged systemic effect. Systox also shows promise in the control of the six-spotted mite. *Possible toxic hazards of this insecticide have not been fully evaluated; consequently its use at present should be confined to nonbearing trees or nursery stock.*

## FALSE CHINCH BUG

The false chinch bug, *Nysius ericae* (Schilling), is a small, light or dark gray bug, about ⅛ inch long (fig. 13). The pale gray nymphs, with reddish brown abdomens, swarm from dry grasslands into adjacent cultivated areas, attacking nearly any green plant. There are from four to seven generations per year. On a number of occasions young avocado trees have been attacked and severely injured. The variety *minutus* Uhler, a small form, is also injurious and has killed young avocado trees. For control of false chinch bugs, DDT or benzene hexachloride dusts have been used with fair success, but more recent experience with 5 per cent chlordane dust in-

Fig. 13. False chinch bug. Above, nymph; below, adult. (× 10.5)

dicates that this material may prove superior to other insecticides used to date. *Observe precautions in the use of this material as indicated on page 4.*

## HARLEQUIN BUG

The harlequin bug, *Murgantia histrionica* (Hahn), is about 3/8 inch long and is black, with red and white markings on its back. Occasionally it attacks avocado trees, particularly near extensive areas of mustard or wild radish, which are breeding plants. It can cause serious injury to young trees, a wilting and discoloration of the foliage. A thorough application of 0.75 per cent rotenone dust or 10 per cent sabadilla dust is effective.

## GREENHOUSE WHITEFLY

The greenhouse whitefly, *Trialeurodes vaporariorum* (Westwood) (fig. 14), which is a general feeder, has occasionally been found in appreciable numbers outdoors on avocado, particularly young nursery trees which at times may be severely attacked.

Various formulations of spray oil with nicotine or pyrethrum have been used with some degree of success in the control of greenhouse whitefly. Oil plus DDT is effective against all stages. Excellent results have been obtained by spraying with 25 per cent parathion wettable powder at 1 pound to 100 gallons. *Parathion is a very toxic material and must be handled and applied with proper safeguards. It should be applied by a commercial operator experienced in the use of the material.*

## APHIDS

Aphids apparently have become sufficiently abundant to be injurious on avocado trees only when the latter are situated close to heavily infested citrus trees. In such instances, the species on avocado have been the same as those on the citrus trees from which they migrated, principally the spirea aphid, *Aphis spiraecola* Patch, and the melon aphid, *A. gossypii* Glover. On avocado trees isolated from citrus trees, the only species the writers have found are the dock aphid, *A. rumicis* Linnaeus (fig. 15), and the cotton or melon aphid, *A. gossypii* Glover. Infestations of these species have been confined to an occasional succulent twig terminal.

Nicotine sulfate, oil-rotenone, or TEPP (tetraethyl pyrophosphate) preparations, currently being used for the control of

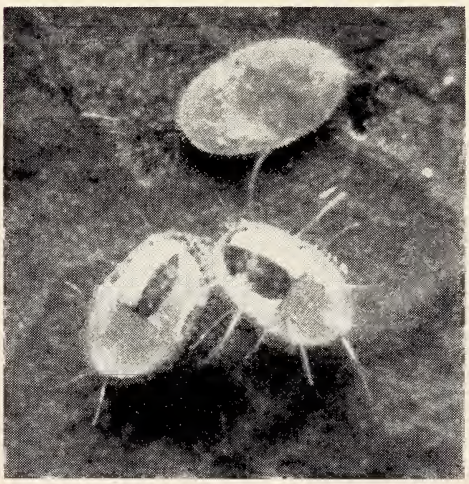


Fig. 14.—Greenhouse whitefly. The two below are pupae with a portion of the dorsum split and showing where the adults emerged. The one above is a nymph. (× 38)

Fig. 15.—Dock aphid feeding on midrib of an avocado leaf. Above, wingless form; below, winged form. (× 23)

aphids on citrus, should also be used on avocados. *Nicotine sulfate and TEPP are very toxic and must be handled with proper safeguards.*

## LONG-TAILED MEALYBUG

The long-tailed mealybug, *Pseudococcus adonidum* (Linnaeus), is the most important of five species of mealybugs that may be found on avocado trees. Injury from this species is practically confined to the scions of newly grafted trees in coastal areas.

**Appearance.** The mealybugs have soft, oval, flattened bodies in which the divisions between head, thorax, and abdomen are not distinct. They are covered with white, mealy wax, and usually have marginal waxy filaments of variable thickness and length, and two long "tail" filaments (fig. 16). The body (without tail) is about 1/8 inch long.

**Development.** Unlike other mealybugs, the long-tailed mealybug bears its young alive. They are born under a thinly woven, cottony network of waxy threads which the female weaves about her body. This affords some protection for the young for a while before they start feeding. The production of young takes place for a period of from 10 to 20 days, with an average of about 200 young produced. An average of about 6 weeks is required for the mealybugs to reach maturity.

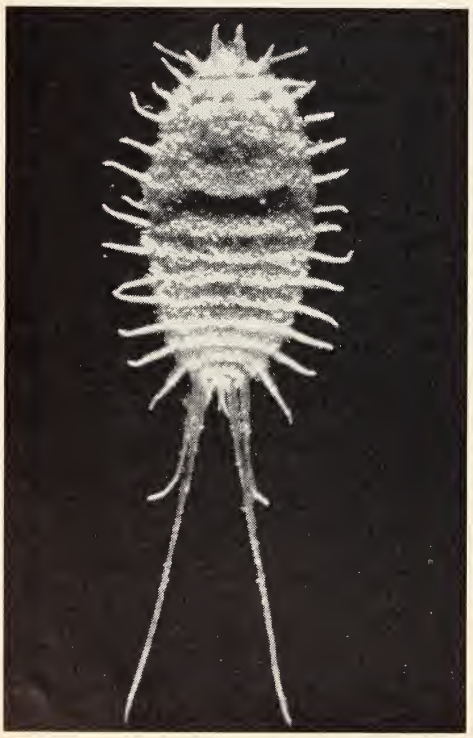


Fig. 16.—Long-tailed mealybug. (× 13)

**Injury.** In recent years much grafting has been done, in the coastal areas, on avocado varieties found to be commercially unsuitable in the localities where they were planted. The scions are covered with paper bags to keep the direct sunlight off the new foliage. The shade afforded by these bags makes it possible for the mealybugs to attack the new foliage. Predators and parasites are not able to control the mealybugs in time to save the scion, which is usually killed unless other controls are employed.

**Control.** In grafting, the trunk or several larger limbs of the trees are cut off and usually two scions are placed in clefts at either side of the sawed-off area. After grafting is done, the top of the trunk or limb and the sides, for about 6 inches from the top, should be treated with chlordane. The following materials have been used with success: 5 per cent chlordane dust; a spray of 50 per cent chlordane wettable powder at about 1/3 ounce to a gallon of water; and a slurry consisting of 2 pounds of 50 per cent chlordane wettable powder to 1 gallon of water. The latter can be painted onto the area to be protected, and since it leaves a greater amount of chlordane on the tree, it should be the most effective method of application. It may also prove to be the most convenient. However, all three methods have resulted in good protection of the scions until the new growth is about a foot long, after which it no longer requires protection. It appears that the effectiveness of the chlordane depends primarily on its ability to control ants.

When the graft cleft is cracked, it is the practice to reseal it, and any insecticide applied before the second application of sealing substance is thereby covered over. In a number of experiments, it was only on trees on which the graft clefts were resealed after the application of the insecticide that more than an occasional mealybug was found. The grower should be notified if and when the graft clefts are to be resealed, and the insecticide should be reapplied to the affected trees.

DDT spray as used for greenhouse thrips results in a reduction of the mealybug population for at least a half year after treatment. It may also be used as recommended above for chlordane.

## UNARMORED SCALES

Among the unarmored scales attacking the avocado are the soft scale, *Coccus hesperidum* Linnaeus (fig. 17), hemispherical scale, *Saissetia hemisphaerica* Targioni, black scale, *S. oleae* (Bernard), and the European fruit lecanium, *Lecanium corni* Bouché. These are all quite effectively controlled by parasites, and rarely increase to more than a localized infestation on an occasional tree in the orchard. If treatment appears to be necessary, these insects can be controlled by means of oil spray, provided the treatment is timed to coincide with the occurrence of the young, vulnerable instars, or provided repeated applications of spray are made to insure the control of the progeny of those insects which may have been resistant at the time of treatment. Malathon is very effective against the soft scale. Control of ants will aid in combating unarmored scales.

## LATANIA SCALE

The latania scale inhabits many regions of the world on a wide variety of hosts. In California, however, it was practically unknown until a survey made by state and county officials in 1928 revealed that it was at that time the principal scale pest of the avocado. Orchards were sprayed or fumigated for this pest. Gradually the latania scale became less serious as a pest, apparently because of the increasing importance of natural enemies, some of them introduced in recent years. Today, growers seldom treat for latania scale, although sometimes it becomes rather abundant on a few scattered trees and causes some degrading of fruit. It is generally believed, however, that the benefits of treatment would ordinarily be more than offset by the upsetting of the natural balance between the pest and its natural enemies.

Fig. 17.—Various stages of the soft scale. (× 5.5)

**Appearance.** The latania scale (fig. 18) is by far the most common of three species of grayish, circular, flattened, armored scales that may be found on avocado trees. The latania scale is circular, $\frac{1}{16}$ to $\frac{1}{12}$ inch in diameter, and rather strongly convex. If the hardened, grayish armor of the insect is lifted off, the soft yellowish body may be seen.

**Development.** Upon turning over the scales, one may often find the yellow eggs, or the sulfur-yellow, active young "crawlers" that hatch within a few hours.

Fig. 18.—Small, seedless avocado ("cuke") with latania scale. Note pits caused by the scales. (× 2.6)

These usually settle near the parent within a half a day after hatching and, like other armored scales, begin secreting the wax that forms the scale covering. In about 2 weeks the insect undergoes its first molt, the molting process requiring 2 or 3 days. In 16 to 19 days after the first molt, the second molt occurs, and the insect enters the adult stage. Males have been recorded by several authors, but have not been found in California. Isolated females lay eggs, proving that they can reproduce without fertilization. In about a month after the second molt, crawlers appear. It has been found that in summer the life cycle of the latania scale is about two months.

**Injury.** The latania scale is usually most abundant on the branches or twigs, but may appear on the leaves and fruit as the infestation increases. The smaller twigs may be killed. The fruit is degraded or culled because of the presence of the scales on the peel, although the quality of the fruit is not affected. On the Fuerte and possibly on other thin-skinned varieties, the beak of the scale appears to cause an irritation in the flesh, as indicated by nodules adhering to the inside of the peel when it is removed. Corresponding depressions occur in the flesh of the ripe fruit. The Anaheim appears to be the most severely attacked of all varieties.

**Control.** Malathon 25 per cent wettable powder at 3 pounds, or the 50 per cent emulsifiable solution at 1½ pints to 100 gallons, is effective against the latania scale as well as the greenhouse thrips, omnivorous looper, orange tortrix, and soft scale, and it does not aggravate the mite problem. No "off flavor" was detected in Fuerte avocados after treatment with malathon at the above concentration. Light medium spray oil, emulsives at 1¾ per cent, and emulsions at 2 per cent can also be used in the control of the latania scale. However, an oil spray may not suffice to control a severe infestation of latania scale, particularly when the scales are so abundant that their bodies overlap. In addition, oil spray is sometimes injurious to the trees and may reduce the crop for the following year.

A spray of 25 per cent parathion wettable powder at 2 pounds to 100 gallons, as it has been widely used in the control of the red scale in citrus, has shown promise in experiments in which it has been used for the control of latania scale on avocados. In addition, it is highly effective against greenhouse thrips and apparently all other insects, except for the soft brown scale, and has some value against mites. *Parathion is a very toxic material and must be handled and applied with proper safeguards. It should be applied by a commercial operator experienced in the use of the material.*

## OTHER ARMORED SCALES

The greedy scale, *Hemiberlesia rapax* (Comstock), is similar to the latania scale in outward appearance and can be distinguished with certainty only by

**CHECK CHART:**

**On the inside pages of this special section is a quick reference chart of pests attacking avocados, together with recommended control measures. The chart may be lifted out of the circular and hung on a wall as a handy guide.**

## CHECK CHART . . .
## Avocado pests and the recommended control for them . . . IN BRIEF

**CAUTION.** *Insecticides a proper precautions as ind* attending the use of parath it is likely to be used expe be applied by an experienc

| PEST | TREATMENT |
|---|---|
| Six-spotted mite | Fifteen per cent Aramite wettable powder at 2 pounds, 25 per cent wettable powder at 1¼ pounds (or 25 per cent emulsifiable solution at 1¼ pounds) to 100 gallons; 50 per cent Ovotran wettable powder at 1 pound (or 25 per cent emulsifiable solution at 2 pints) to 100 gallons; 40 per cent Sulphenone wettable powder at 2 pounds (or 25 per cent emulsifiable solution at 3 pints) to 100 gallons. |
| Avocado brown mite | Sulfur dust. |
| Broad mite (in greenhouses) | Sulfur dust (several applications). |
| Greenhouse thrips | Fifty per cent DDT wettable powder at 2 pounds to 100 gallons or 25 per cent malathon wettable powder at 2 pounds to 100 gallons. |
| False chinch bug | Five per cent chlordane dust. |
| Harlequin bug | A 0.75 per cent rotenone dust or 10 per cent sabadilla dust. |
| Greenhouse whitefly (on nursery trees) | Light medium oil at 1½ per cent with nicotine, pyrethrum, or DDT; or 25 per cent parathion wettable powder at 1 pound to 100 gallons. |
| Long-tailed mealybug (on scions of newly grafted trees) | A slurry of 50 per cent chlordane wettable powder, at 2 pounds to a gallon, painted on the top of the grafted trunk or limb and down the sides for 4 inches. |
| Scale insects | Two per cent light medium summer spray oil emulsion. Twenty-five per cent malathon wettable powder at 3 pounds to 100 gallons may be used against latania scale and soft scale. |
| Omnivorous looper | Fifty per cent DDT wettable powder at 1 pound to 100 gallons. Double the dosage if control of greenhouse thrips is desired. |

*poisonous to humans and should be used with* *ted on page 4.* Because of the particular hazard , it is recommended that in the few cases in which ientally in the control of certain avocado pests it commercial operator.

| PEST | TREATMENT |
|---|---|
| Amorbia | As for omnivorous looper. |
| Orange tortrix | Fifty per cent DDD wettable powder at 2 pounds to 100 gallons. |
| Variegated cutworm (on young trees) | Poison bait scattered beneath trees. |
| Darkling ground beetle (on young trees) | Poison bait scattered beneath trees. |
| June beetles (on young trees) | Five per cent DDT dust. |
| Bronze willow flea beetle | Fifty per cent DDT wettable powder at 2 pounds to 100 gallons. |
| Fuller rose beetle | Five per cent chlordane dust. |
| Adaleres beetle (on young trees) | Apply sticky banding material on trunks of trees. |
| Ambrosia beetles | Paint affected parts of trunks and limbs with 5 per cent DDT in kerosene. |
| Fire ant | Five per cent chlordane dust. |
| Argentine ant | Five per cent chlordane dust or a slurry of 50 per cent chlordane wettable powder applied to trunk. |
| European brown snail | Poison bait scattered beneath trees. |
| Rats and gophers | Trapping, poisoning. |

**Spreaders.** Avocado leaves are wet with difficulty. The most effective spreaders should be added to the sprays at concentrations required to wet both sides of the leaves adequately with the particular brand of spreader being used.

microscopic examination of properly mounted specimens. In California this species is less abundant than the latania scale on avocado trees. However, an instance of injury to young avocado trees has been called to the writers' attention. In a three-year-old orchard it was found that greedy scale had become abundant under newspapers that had been wrapped around the trunks of the trees to protect them from the sun. The trunks in some instances were somewhat distorted by the scale infestation and it was believed that the resulting weakness caused them to break more readily in strong winds. The control of these scales, if necessary, would be the same as for latania scale.

The oleander scale, *Aspidiotus hederae* (Vallot), like the greedy scale, is not readily distinguished from the latania scale, but may be identified with properly prepared specimens. In a survey made by the State Bureau of Entomology and Plant Quarantine in 1930, 17.6 per cent of the scale-infested avocado trees in California had oleander scale. This insect, however, has never been of appreciable commercial importance. The control, if necessary, would be the same as for the latania scale.

The dictyospermum scale, *Chrysomphalus dictyospermi* Morgan, is a circular, armored scale, $\frac{1}{16}$ to $\frac{1}{12}$ inch in diameter, with armor yellowish brown to brown in color. A survey in 1930 showed the dictyospermum scale to be quite abundant on avocado trees in residential properties in Whittier, California, at that time, but very scarce in commercial orchards. After the known infestations of some importance were controlled, this insect never again increased to noticeable infestations on the avocado in the Whittier area, but has occasionally been found and eradicated on dooryard avocado trees in Santa Paula and near-by districts in Ventura County.

The California red scale, *Aonidiella aurantii* (Maskell) is circular, reddish in color, and averages in size about the same as the previous species. This scale insect, if it is present at all, will usually be found only on occasional trees in the orchard, generally in proximity to some more favored host, such as citrus. Sometimes a tree may be severely attacked (fig. 19) while neighboring trees are entirely free of the insects. An exception to the generally spotty distribution of the red scale in an avocado orchard was a rather heavy infestation in a 15-acre orchard of the Fuerte and Ryan varieties at Monrovia, California. The orchard was sprayed with $1\frac{2}{3}$ per cent light medium oil, with good results, on January 25–26, 1946.

Fig. 19.—California red scale on an avocado leaf. (× 0.66)

## OMNIVOROUS LOOPER

As the common name implies, the omnivorous looper, *Sabulodes caberata* Guenée, feeds on a large number of plants. The term "looper" derives from the crawling habits that the insect shares with other species of the family. "Legs" are absent from the middle of the body and there are only two or three pairs at the hind end. The larvae must pull these up close to the true legs, located at the front end, thus looping their bodies (see picture, inside front cover). Then the "legs" are firmly attached to the leaf and the fore end of the body is thrust forward.

Leaves that have been partly devoured by the omnivorous looper may be found on almost any avocado tree, and occasionally severe defoliation may occur. The insect sometimes feeds on the fruit as well as the foliage, however, and it is under these conditions that it becomes a serious pest. Fruit damage seems to have become serious only in recent years. *It is gradually increasing in importance.*

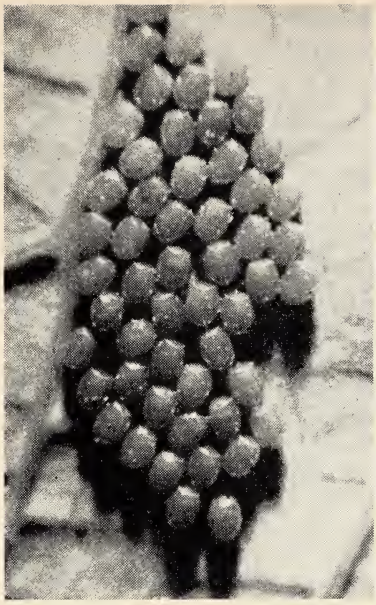
**Appearance.** The adult moth (fig. 20) is dull brown or yellow above and nearly white beneath. Two irregular, darker, transverse median bands cross the upper surface. It has a wing expanse of about 2 inches. These attractive moths are seldom seen during the day because they cling to the undersides of the leaves with their wings spread as shown in figure 20, and fly about only at night.

**Development.** The female lays from 200 to 300 eggs. These are deposited in clusters on the undersides of the leaves, each cluster consisting of from 3 to 80 eggs resting horizontally on the leaf surface (fig. 21). They are at first metallic green, but in 2 days turn to a chocolate brown. They hatch in 8 or 9 days.

The first-instar larva is at first pale yellow and is the same length as the egg. It eats only the epidermis of the upper surface of the leaves, leaving a characteristic brownish membrane. All the other larval instars eat all the way through the leaf. Looper larvae may eat holes into the leaf away from the margin, but are more likely to eat their way in from the margin of the leaf.

The remaining instars are a yellow to

Fig. 20.—Omnivorous looper. Adult moth with wings in normal position when at rest. (See page 2 for picture of larva.) (× 2.8)



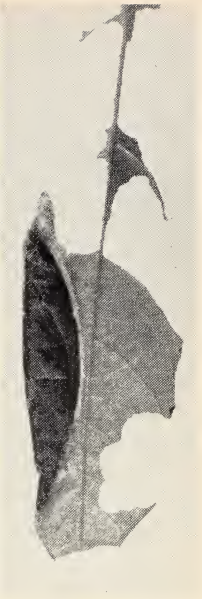


Fig. 21.—Left: a cluster of eggs of the omnivorous looper, greatly magnified. **Fig. 22.**—Protective coverings for pupa of the omnivorous looper. Center: two leaves webbed together; right, edge of a leaf folded back and webbed into position. Note feeding injury.

pale green or pink, with yellow, brown, or green stripes on the sides and back, besides a number of black markings. The fifth and last instar of the larval stage (see picture, inside front cover) is 1½ to 2 inches long. The greatest damage is done by this instar. One individual may eat an avocado leaf in a single day.

The pupa may be found webbed between 2 leaves or inside a leaf that has been folded and webbed together by the full-grown larva for the purpose of pupation (fig. 22). It is at first a pearly white, but becomes dark brown as the time for the emergence of the adult approaches. The pupa is about 1¼ inches in length.

The life cycle of the omnivorous looper requires about 1½ months in summer in coastal San Diego County, and apparently there may be 5 or 6 generations per year.

**Injury.** The omnivorous looper usually feeds only on the foliage (fig. 22). If a sufficient percentage of the foliage is removed, the tree is of course weakened and the following year's crop is reduced.

In July, 1949, the first case of extensive damage to fruit was seen in an orchard near Vista, California. Young fruits of the Fuerte variety, about 1 to 1½ inches long, were being attacked by omnivorous looper larvae of the second and third instars. These caused shallow feeding scars on the rind (fig. 23, top) and affected about half the crop in the infested orchard. Although the larvae were killed by a DDT spray, and further infestation in the affected orchard was prevented, it was noted that subsequent instars ate out holes as much as ¼ inch in depth in the fruit in the laboratory (fig. 23, bottom), the resulting injury appearing much like that caused by snails. These larvae were reared to maturity on a diet of fruit alone.

Omnivorous loopers will attack the fruit even when it is not adjoining another fruit or a leaf. In this respect they differ from other moth larvae to be discussed later.

**Control.** Before DDT, lead arsenate spray was recommended as a control measure. The formula was 4 pounds of acid lead arsenate and 6 ounces of blood

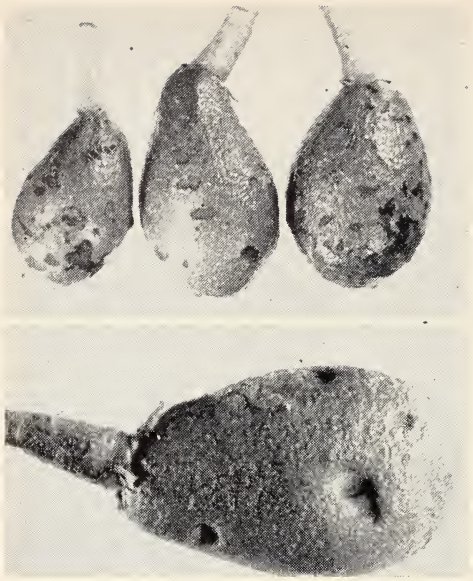


Fig. 23.—Above: shallow grooves eaten into peel of young avocados by early instars of omnivorous looper; below, deep pits eaten out by later instars. (× 0.8)

albumin spreader to 100 gallons of water. This spray was not found to be entirely satisfactory as a control.

It has been noted that in the considerable acreage that has been sprayed with DDT for greenhouse thrips the omnivorous looper has not become a pest. About an hour after the spray is applied, the larvae begin to fall to the ground in a paralyzed condition. When collected and brought to the laboratory, they die within 10 or 12 hours. Even though the larvae may be protected from the spray by a cover of leaves during the day, they will succumb to the spray residues when crawling about and feeding at night. One pound of 50 per cent DDT wettable powder to 100 gallons is effective. If control of greenhouse thrips is desired, the amount of DDT used in the spray should be doubled.

## AMORBIA

This moth, known as *Amorbia essigana* Busck, is a tortricid (leaf roller) moth that was first recorded in California in 1922. It has been found in all coastal counties in southern California and seems to prefer the avocado as a host. The amorbia is generally not so abundant as the omnivorous looper, and the fact that it can feed on fruits only where they may be in contact with one another, or with a leaf, further reduces its importance as a pest.

**Appearance.** The adult moth (fig. 24) has a wing expanse of 1 inch, being only a little over half the size of the omnivorous looper, and the forewings are reddish brown. The moths, when at rest, have the bell-shaped outline that so frequently characterizes the leaf rollers. The outer corner of the forewings is usually somewhat notched. The adults are nocturnal, and rest on the undersides of the leaves during the day.

**Development.** The amorbia lays its eggs on the upper surface of the avocado leaf, along the midrib. The greenish eggs are laid in flat masses of from 5 to 100, and from 400 to 500 eggs may be laid by a single moth. These hatch in from 13 to 15 days.

Although there may be as many as seven larval instars, pupation may take place after the fifth or sixth instar. The first-instar larva is small and yellowish green. The larvae of the remaining instars are similar in appearance, except for size, the seventh-instar larva being ¾ inch to 1⅛ inches long (fig. 25, top). Larvae of all instars usually spend the day hidden between two leaves that have been webbed together, or between a leaf and a fruit (fig. 26), in this habit re-

Fig. 24.—Amorbia with wings folded in rest position. (× 3.4)

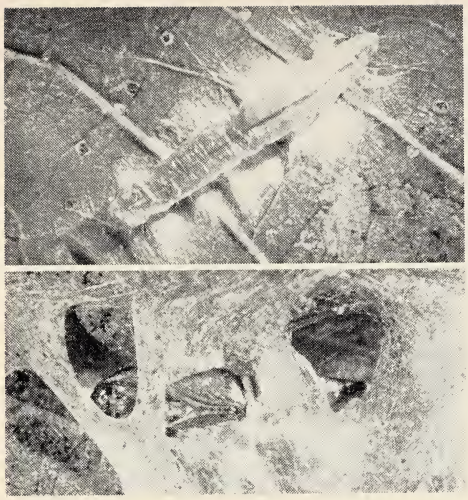


Fig. 25.—Above: amorbia larva attaches itself to a leaf before pupating; below, pupa with protective webbing partly removed. In both cases, one of the two attached leaves was withdrawn to reveal the insect. (× 1.5)

sembling the larvae of the omnivorous loopers. The larvae wriggle violently and fall to the ground if their hiding place is molested. The duration of the larval stage, including seven instars, was found to be about two months under outdoor conditions in late summer.

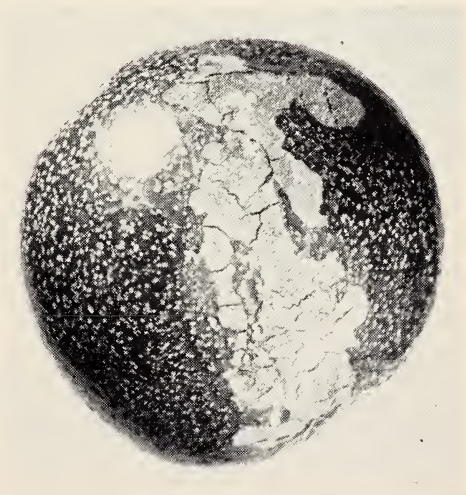
The pupa (fig. 25, bottom) is from ½ to ¾ inch long. At first it is pale green, later changing to chocolate brown. As in the case of the omnivorous looper, the larvae web two leaves together to conceal themselves during pupation. The pupal stage requires an average of 17 days in summer.

**Injury.** On the leaves, the amorbia causes a skeletonizing similar to that caused by the omnivorous looper. Sometimes the terminal leaves of a twig are tied together by means of silken threads, and the larva will feed on the terminal bud. The larva will also feed on fruit if a hiding place is provided, such as an adjoining leaf. The young fruits are the ones most likely to be attacked, and the scars caused by the feeding become enlarged and more conspicuous as the fruit matures (fig. 27).

In August, 1949, amorbia larvae, together with larvae of the orange tortrix, *Argyrotaenia citrana* (Fernald), were found to be destroying the buds of newly budded avocado trees. The larvae fed on the bark adjoining the inserted buds, on the buds themselves, and on any growth that may have developed from the buds. They were found only under the tape that is used to keep the buds in place.

**Control.** As for omnivorous looper, p. 21.

Fig. 26.—Above: left, leaf webbed to an avocado, under which an amorbia is feeding on the fruit peel; right, leaf turned over to reveal webbing that conceals larva during the day, and the scar on fruit, indicating area over which larva has fed. **Fig. 27.**—Below: injury caused by amorbia, as it appears on mature fruit.



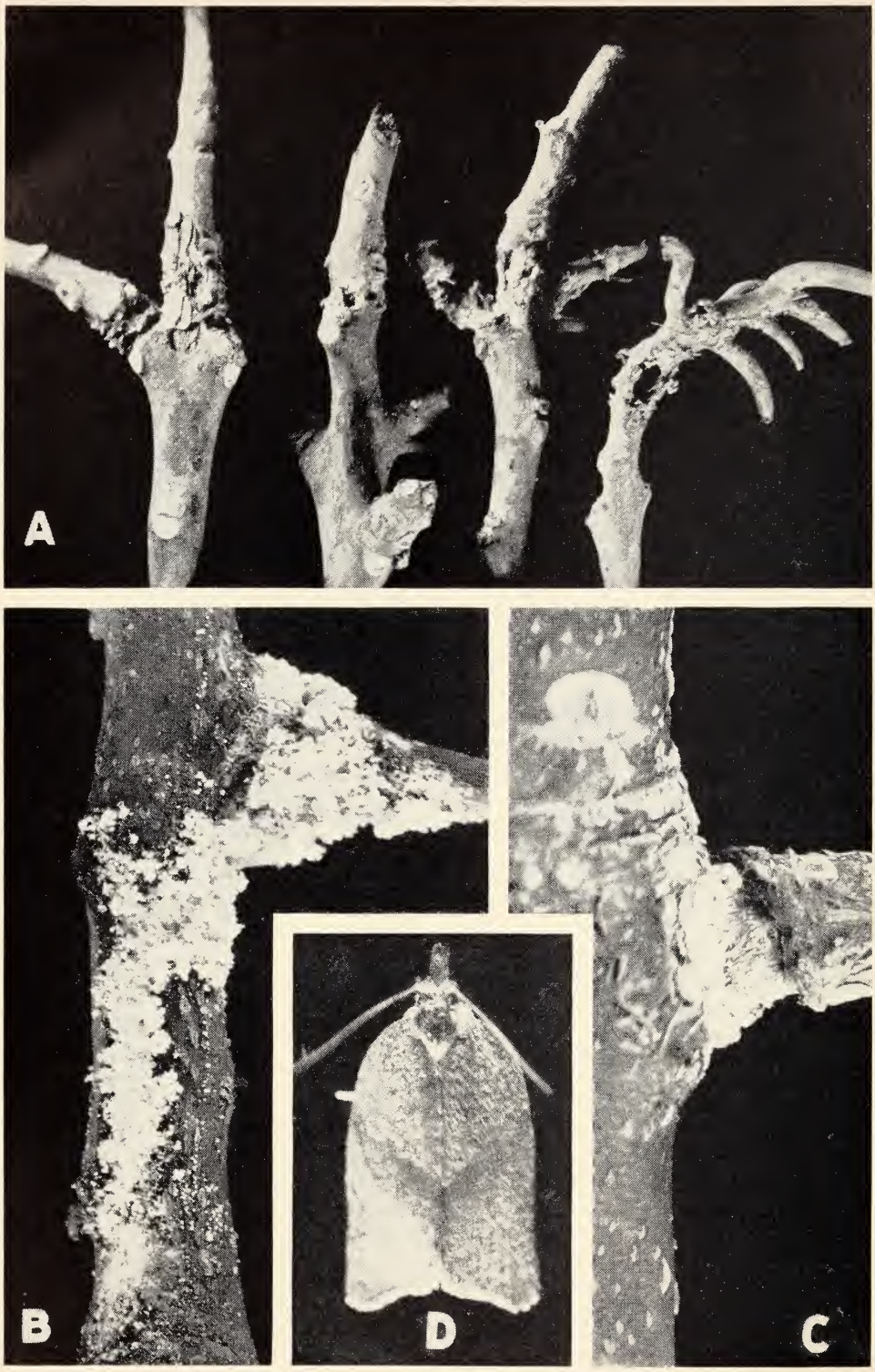



Fig. 28.—Orange tortrix on avocado. A, damage to bark of peripheral twiglets; B, the white, powdery "dulcitol" that has exuded from wounds made by an orange tortrix larva; C, girdling of the bark at base of a twig revealed after dulcitol has been removed; D, adult moth (× 5).

## ORANGE TORTRIX

The orange tortrix, *Argyrotaenia citrana* (Fernald) is a small leaf-roller moth that has been known as an orange pest in California for many years. In 1949 this insect was found to be doing a limited amount of damage to avocados by feeding on green twigs and fruit. It appears to be increasing in abundance on the avocado.

**Appearance.** The adult females have a wingspread of about ⅔ inch, and the males are somewhat smaller. The moths are buff-colored, and their bell-shaped wings lie almost flat over the body (fig. 28, *D*). Usually each wing has a dark, diagonal band.

**Development.** Masses of pale-green or cream-colored eggs, overlapping like shingles, may be found on leaves or smooth green bark. There may be 5 to 7 larval instars. The full-grown larvae are about ½ inch long, and may be straw-colored, light tan, greenish, or rather smoky-colored (fig. 29). Like the larvae of the amorbia, they are very active and will wriggle away and drop to the ground when disturbed, or remain suspended on a silken thread on which they can climb again. The pupae are about ⅓ inch long, and are brown in color. They suspend themselves by means of small hooklets at the narrow hind end of the body.

In the laboratory, about two months at room temperature are required for the development of one generation. Out of doors, in the coastal regions, various stages of development may be observed at any time of the year, but there are probably about three generations per year.

**Injury.** On avocados the most frequent injury occurs near the periphery of the tree on terminal twiglets. The larvae feed on the green bark and often girdle the twigs (fig. 28, *A*), sometimes eating holes in them. While feeding, the larvae are covered by crude "nests" of plant debris, and it is these nests that attract attention to the feeding. Like the amorbia, the orange tortrix may also web the terminal leaves of twigs together and feed inside on the terminal buds. Likewise the bases of larger twigs may be girdled at the point of their attachment with larger branches (fig. 28, *C*). The injured area in such cases is usually covered with a white sugar, called "dulcitol," that exudes from the wound (fig. 28, *B*).

During the blooming period the tiny larvae are sometimes found inside the flowers, where they may feed on the developing embryo or the calyx. The same larvae may later form a nest of several flower heads and feed on the bases of the flowers or farther down in the long stems of the flower clusters. "Nests" of flower parts may sometimes be found at the point where several stems of the flower clusters are joined, and the larvae may be found feeding under the nests.

Like the amorbia, the orange tortrix may attack the terminal bud after tying together the tender terminal leaflets for a hiding place. It may also destroy the buds of newly budded trees. The tape holding the bud in place gives the same type of protection ordinarily afforded by the nests of debris.

Fig. 29.—Orange tortrix larva and injury caused to avocado twig. The "nest" of debris and the dulcitol have been removed to expose larva. (× 2)

The most serious injury to date has been the scarring of fruit caused by the feeding of the larvae. The injury appears much like that caused by the omnivorous looper. As with the amorbia, the extent of damage in an orchard is limited by the fact that the larvae will feed only at the point of contact of two fruits or where the fruit may be in contact with a leaf.

**Control.** Spraying with 2 pounds of 50 per cent DDD wettable powder to 100 gallons is effective in controlling the orange tortrix, and the same treatment is also highly effective against the omnivorous looper and the amorbia.

## HOLCOCERA

A small, slender, grayish moth, about ⅓ inch in length, known as *Holcocera iceryaella* (Riley) (fig. 30, left), and at least one other closely related species (fig. 30, right) are primarily scavengers, but occasionally feed on live plant or animal material. Their nests (fig. 31) are much larger and more carefully formed than those of the orange tortrix, but are not so numerous. Occasionally they are attached to a leaf. The larvae when full-grown are on the average slightly longer than the moths. They are brownish, with broken, longitudinal stripes. They usually feed only on the debris of which their nests are constructed, but sometimes will make a shallow channel in the green bark of the twig beneath their nest. Only rarely do they feed deeply into the twig. To date they have proved to be of practically no economic importance on avocados.

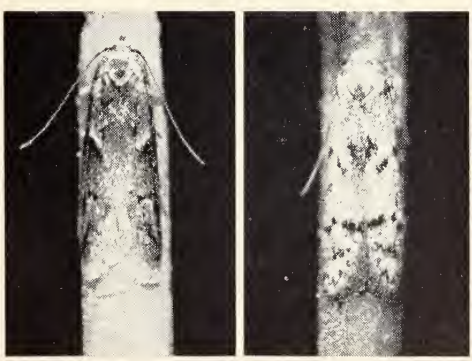


Fig. 30.—Two species of Holcocera that sometimes eat shallow channels into the green bark of avocado twigs. Left, H. iceryaella; right, a closely related species. (× 3.7)

Fig. 31.—"Nests" of the Holcocera species on avocado twigs.

## VARIEGATED CUTWORM

Among the sporadic pests that occasionally attack young avocado trees, particularly near large, uncultivated areas. is the variegated cutworm, *Peridroma margaritosa* (Haworth). The adults are grayish brown moths with dark mottled forewings and a wing expanse of 1½ to 2 inches. This is one of the night flying moths or "millers" commonly attracted to lights.

The full-grown larvae are about 1½ inches long, variable in color, but usually gray or brown, mottled above with gray or darker lines, and often with oblique gray areas on the sides. They feed on all kinds of vegetation. They may be controlled with commercially prepared poison baits. The bait should be scattered about under the trees just before dusk.

## LEAF MINER

A narrow, light-colored, serpentine pattern on the green twigs of avocado trees, and occasionally on the foliage and fruit, indicates the presence of a leaf

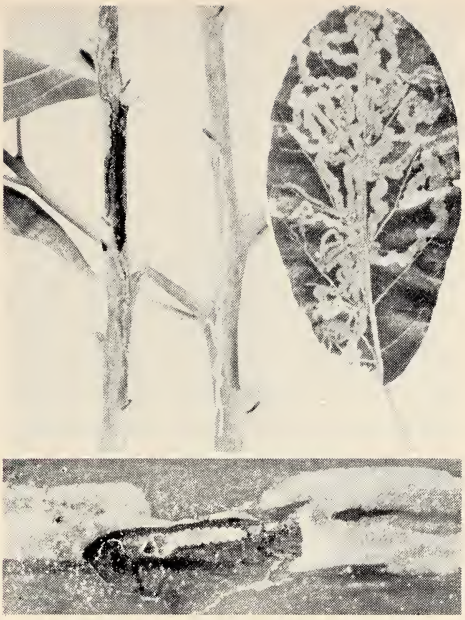


Fig. 32.—A leaf miner, Marmara salictella. Above: serpentine mines in avocado twigs (left) and in a leaf (right); below, larva exposed in its mine, greatly enlarged.

miner, *Marmara salictella* Clemens. The small, reddish larvae of these tiny moths bore beneath the epidermis, leaving the characteristic markings (fig. 32). The native host of this species is the willow, and occasionally avocado trees growing near willow are rather heavily infested, although no economically important damage has ever been reported. The work of these leaf miners is most commonly seen in nurseries or young orchards. The insect is worthy of note here mainly because of the curiosity aroused by its markings on avocado or citrus twigs, leaves, or fruits.

## DARKLING GROUND BEETLE

These shining black or brown beetles (fig. 33), of the species *Coniontis subpubescens* Le Conte, are about ⅓ inch long and are recorded as being injurious to sugar beets in southern California. They are a native species that may fly into cultivated areas from the surrounding hills in enormous numbers. About the middle of April, 1949, these insects were found attacking newly planted avocado trees in Ventura County. These trees were protected with shingles. The beetles climbed up the shingles and ate the foliage adjoining them, but did not appear to be climbing up the trunks of the trees. At least no foliage was eaten that was not in contact with the shingles. The beetles were effectively combated with poison bran mash spread on the ground around the trees.

## BRANCH AND TWIG BORER

Occasional examples of severe injury to avocado trees from the branch and twig borer, *Polycaon confertus* Le Conte, have been noted since the earliest days of the avocado industry in California. The borers leave unmistakable signs of their work and can therefore be readily located. The entrances of the burrows made by the adults on avocado trees are very conspicuous, for the sugary sap ("dulcitol") that exudes becomes flaky or powdery and turns white (fig. 34), as in the case of injury by orange tortrix. Infested branches are easily broken by wind.

This beetle (fig. 34) is black with brown wing cases, cylindrical, and ¼ to ⅝ inch long. The adults burrow into the crotches or bud axils of native trees as well as apparently all kinds of fruit and nut trees in California and parts of Oregon. The robust, curved, whitish larvae

Fig. 33.—Darkling ground beetles. (× 3)

Fig. 34.—Branch and twig borer on avocado twigs. The adult beetles (arrows), their exit holes, and the surrounding white, powdery substance (dulcitol) are shown. (Slightly enlarged.)

Fig. 35.—June beetles. Above: Serica fimbriata (× 1.3); below, Coenonycha testacea. (× 1.2)

burrow farther, completely mining the heartwood.

Apparently the only practical control measure, especially since the infestations are so sporadic and unpredictable, is to prune off and burn the infested branches or twigs. Native or cultivated trees in surrounding areas should be examined for possible sources of reinfestation.

## JUNE BEETLES

Of the June beetles attacking avocados, the species *Serica fimbriata* Le Conte and *S. alternata* Le Conte are the most familiar to the avocado grower. They are found in practically any locality and attack many trees and other crops besides the avocado. These species are rather large and robust, *S. fimbriata* being ½ inch and *S. alternata* ⅜ inch long. The former is a smooth or velvety brown, with faintly striped wing cases (fig. 35, top), while the latter is of a uniform shiny brown color.

June beetles are most injurious in young orchards planted near uncultivated land. They fly in from their breeding places in untilled fields and brush land and eat the foliage on the trees at night. They may completely defoliate hundreds of trees in a single orchard. During the day they burrow into the soil to a depth of from ½ inch to 2 inches and reappear the following night to resume their feeding.

*Coenonycha testacea* (Cazier) (fig. 35, bottom) occurs over a wide area in California on certain species of native vegetation, including wild buckwheat and rabbit brush. It was first found on avocado trees in an orchard 2 miles south of Fallbrook, California, in February, 1946. Here the beetle did severe damage, stripping the foliage from young trees and completely destroying a small avocado nursery by feeding on the buds of newly budded seedlings. The beetle reappeared in the same orchard the following year, as well as in neighboring orchards, and has been steadily increasing the range of its feeding on avocados in the Fallbrook area since 1946.

*Coenonycha testacea* belongs to the same family (Scarabaeidae) as the *Serica* beetles, but is smaller and distinctly narrower. This beetle measures about ⅓ inch in length and 1/7 inch in width, and approaches a rectangular shape in contrast to the broadly oval shape of the *Serica* beetles. *C. testacea* is shiny yellowish brown in color. This species first begins to feed on avocado foliage very early

Fig. 36.—Bronze willow flea beetle feeding on a young avocado. (× 1.25)

Fig. 37.—Banded flea beetle. (× 6.2)

(late January or early February) and is found in appreciable numbers for only about a month. The *Serica* beetles appear about 3 months later, but the period of their activity is much longer.

**Control.** All three species discussed above are readily controlled with 5 per cent DDT dust. Control can be effected by applying the dust either to the foliage or to the ground beneath the tree. In either case the beetles get enough DDT on their feet as they crawl about to result in their death. Probably the application of the dust both on the tree and on the ground would insure the best results. It is important to apply the insecticide when the beetles first appear, for they can do much damage in a few nights.

## BRONZE WILLOW FLEA BEETLE

The bronze willow flea beetle, *Diachus auratus* (Fabricius) is a small, metallic bronze insect 1/12 inch or less in length. It occurs in many parts of North America and South America and is common on willow in New Mexico, Arizona, and California. It has caused damage to tender shoots of prune trees in California. In July, 1949, this beetle was found feeding on avocado fruits in an orchard near Santa Paula, California, causing a conspicuous scar on the peel (fig. 36). About 10 per cent of the fruit was affected. These beetles also feed on tender avocado foliage and could probably do much damage to seedlings or young trees. Infestations to date, however, have been found only in older orchards.

A spray of 2 pounds of 50 per cent DDT wettable powder to 100 gallons was used with success in the control of the bronze willow flea beetle in one orchard. A powdered "deposit builder" at 1/3 pound to 100 gallons was added to increase the deposit of DDT.

## BANDED FLEA BEETLE

The banded flea beetle, *Systena taeniata* (Say), is a yellowish or brownish insect 1/8 to 1/5 inch in length (fig. 37). It has a reddish head and two lateral black stripes on each wing cover, one of these bordering the inner margin. This species was found attacking newly planted avocado trees near Fillmore, California, in the latter part of August, 1949. The beetles fed on the foliage (fig. 38) and sometimes caused the death of the infested trees.

This species occurs throughout the United States. The beetles lay their eggs on the host plants, usually near the ground. Among the hosts are various weeds, truck crops, and grapevines, and the pear also has been listed as a host. The slender, white larvae live in the soil, where they pupate.

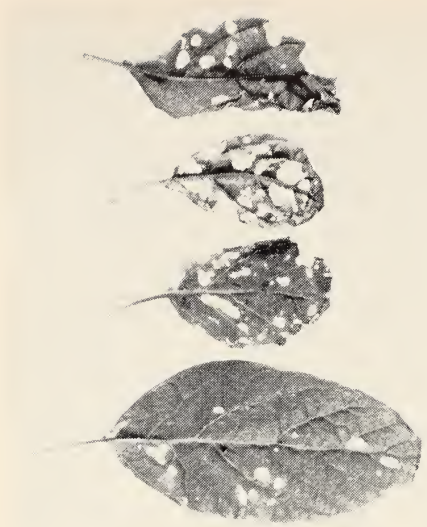


Fig. 38.—Injury to avocado leaves caused by the banded flea beetle. (× 0.3)

## FULLER ROSE BEETLE

The Fuller rose beetle, *Pantomorus godmani* (Crotch) (fig. 39), is about 3/8 inch long and is a uniform pale brown. It feeds on the younger foliage of avocado trees and may at times do some damage to the younger trees. The smooth, elliptical, pale yellow eggs are laid in masses under the bark, on the ground near the trees, or near the bases of smaller plants. The legless white larvae live on the roots of various plants, and pupate in the soil. Because the adults are unable to fly, it is possible to prevent their ascent by applying a sticky banding material to the trunks.

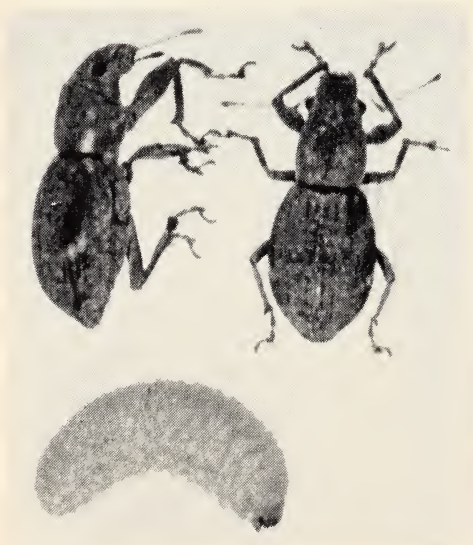


Fig. 39.—Fuller rose beetle. Above: adults; below, larva. (× 4)

If sticky banding material is used, it should be applied over an area coated with high-boiling point paraffin to avoid possible injury to the bark. However, the application of a 5 per cent chlordane dust is a simpler method of combating the pest and is very effective. The vegetable weevil, *Listroderes obliquus* Klug, which also occasionally feeds on avocado foliage, may likewise be controlled by means of chlordane dust. *Observe precautions in the use of this material as indicated on page 4.*

## ADALERES WEEVIL

During the fall and early winter of 1949, newly planted avocado trees near Poway, San Diego County, were attacked by adaleres weevils, *Adaleres humeralis* Van Dyke. The females of this species are about 1/2 inch in length, with the males somewhat smaller. These beetles are light to dark brown with a grayish mottling on the wing covers of some individuals. The wing covers have rows of deep punctures (fig. 40). The weevils feed on the foliage and terminal buds, and their feeding can result in the death of young trees. Since they do not fly, they may be kept off the trees by means of sticky banding material.

## SEED WEEVILS

Seed weevils are among the most important pests of the avocado from Mexico to Panama, but no destructive species has been found in the United States. In California a species of weevil known as the broad-nosed grain weevil, *Caulophilus latinasus* Say (fig. 41), may be found in avocado seeds, but only after they have fallen to the ground. It bores through the rotting flesh of the avocado

and enters the seed. It has in a few instances attacked avocado seeds planted in nursery seed beds. The resulting seedlings are less thrifty and may fail to reach sufficient size for budding at the proper season.

The broad-nosed grain weevil is about 1/8 inch long, has the typical prolonged snout of the weevils, and resembles the well-known granary weevil, *Sitophilus granarius* (Linnaeus), although darker brown in color.

Fig. 40.—An Adaleres beetle (Adaleres humeralis Van Dyke), and batch of eggs laid by beetle, in captivity, on avocado leaf. (× 2.25)

## AMBROSIA BEETLES

Occasionally avocado trees that may appear to be somewhat weakened, yet yield good crops and are commercially desirable, are attacked by small beetles that cause the trunk and larger limbs to be riddled with small holes. Specimens from one infested tree were found to be small, cylindrical, brownish to black ambrosia beetles, *Xyleborus xylographus* (Say) and *Monarthrum* sp., the former (fig. 42) being the more numerous of the two species.* These beetles infest many native trees in California. They often extend their brood chambers deep into the

* The beetles were identified by Peter Ting, at that time with the Division of Entomology, California State Department of Agriculture.

Fig. 41.—Work of the broad-nosed grain weevil on planted avocado seeds. (× 0.37). Inset: adult weevil. (× 10)

Fig. 42.—Ambrosia beetles, Xyleborus xylographus (Say). (× 14.3)

heartwood of the trees they attack and in these chambers they culture ambrosia fungi that serve as food for the larvae. In vigorous trees the flow of sap drowns out the eggs and larvae. These beetles are no threat to healthy trees, but may accelerate the death of weakened trees.

The beetles have been controlled by applying a solution of 5 per cent DDT in kerosene to the infested areas of the bark by means of a paint brush.

## FIRE ANT

The fire ant, *Solenopsis geminata* (Fabricius) (fig. 43), varies in length from $\frac{1}{25}$ inch in the worker to $\frac{1}{4}$ inch in some of the winged forms. The workers are pale yellowish or reddish with black abdomens. The winged forms may be of the same color as the workers or they may be entirely shining black or entirely reddish. They are capable of stinging severely.

*S. geminata* as well as the subspecies

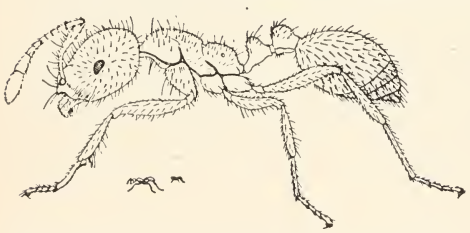


Fig. 43.—Fire ant (Solenopsis geminata), worker. (After Woodworth.)

*maniosa* Wheeler are occasionally injurious to avocado. They have girdled and killed young trees. Some believe the ants injure the bark in order to bring about a flow of sap, upon which they feed. The avocado tree "bleeds" copiously when injured. A 5 per cent chlordane dust, applied to the trunk and the soil about the base of the trunk, has been successfully used in the control of this pest. *Observe precautions in the use of this material as indicated on page 4.*

## EUROPEAN BROWN SNAIL

The European brown snail, *Helix aspersa* (Müller), is a pest of citrus and avocados in the relatively humid and cool coastal areas in California. The shells of this species are of a grayish-yellow and brown color. When fully developed, the shells have either five or four and one-half whorls and are 1 inch or more in diameter (fig. 44).

On avocados the snails feed on the foliage and also on the blossoms and very young fruit, causing scars. During the late winter and early spring months, which is the period when the snails are the most active, they can be controlled by poison bran mash scattered under the trees, as recommended for citrus—about 1 pound to an average-size tree. Ducks and geese are often allowed to run loose in avocado orchards to keep the snails under control by eating them.

## RATS

The principal rodent pests of the avocado are the rats, which feed on the fruit. Until 1950 the rats that appear to have done the most damage are two subspecies: the roof rat, *Rattus rattus alexandrinus* (Geoffroy), sometimes called the Alexandrine or gray rat (fig. 45), and the black rat, *Rattus rattus rattus* (Linnaeus). The roof rat is the one most likely to occur in the avocado orchard. It may attain an over-all length of 15 inches, with a tail measuring 8.5 to 10 inches. Its weight seldom exceeds 8 ounces. It

Fig. 44.—Above: brown snail (× 2.4). **Fig. 45.**—Below: roof rat in avocado tree. (× 0.46)

has a sharp and slender nose, rather large ears with little or no hair, and a thin, tapering, scaly tail which is almost always longer than the head and body combined. This subspecies has a gray or gray-brown back and sides, and the belly is white or nearly white.

The roof rats have about 6 young per brood and may breed several times a year. They inhabit both coastal and inland areas in California and are found in rural districts as well as in cities; in fact, this subspecies has been found in small numbers in the mountains as high as 5,000 feet elevation. They are found in houses, warehouses, feed stores, etc., like the Norway rat, but are also found outdoors, sometimes living along stream banks. They are good climbers, often nesting in trees and dense hedges and vines.

The black rat resembles the roof rat except for its almost solidly black color. It is found only near salt water, such as in seaports and adjacent towns, but may be found in some coastal avocado orchards.

In 1950, in San Diego County, there was a particularly severe loss of avocado fruit caused by damage from rats, and it was reported that the Norway rat, *Rattus norvegicus norvegicus* (Erxleben) was the chief offender. This is the largest of the alien rats, the full-grown individual being about 16 inches long, with a 7½-inch tail, and ordinarily weighing about 11 or 12 ounces. In contrast to the roof rat and black rat, it has a rather blunt nose, and ears of only moderate size. The fur is generally brown, with scattered black hairs, and is darkest along the middle of the back. The under parts are pale gray to yellowish white. The Norway rat has a tendency to displace other species of rats wherever it occurs and may possibly become relatively more important as an avocado pest.

**Sanitation.** First among the control measures against rats is reduction of nesting and breeding places to a minimum. Avocado growers often have occasion to pile broken avocado limbs in various places throughout the orchard, for soil tillage is not practiced. These afford ideal nesting places for the rats. The removal of these woodpiles, especially when they are scattered throughout the orchard, can be a great help in the rat control program. Empty boxes and scraps of lumber should be piled compactly and neatly on trestles or other supports so as to keep them a foot or more above the ground. Firewood should be piled in separated tiers. Garbage and scraps of edible material should be kept in closed cans or destroyed promptly. Rat burrows in yards or about buildings can be collapsed by means of a pick, crowbar, or shovel.

**Trapping.** Trapping is a very effective control measure. Almost any food that humans eat may be used for bait. The ordinary spring snap trap, in a larger size than that used for mice, appears to be the most effective. Contrary to popular opinion, nothing is gained by wearing gloves when setting traps for rats or mice, or by boiling, washing, or smoking the traps to remove the human odor. Some success will result if the traps are set and baited at once, but trapping is even more effective if the traps are placed and baited, but left unset for 3 to 5 nights before being again baited and set. By this time the rats have overcome their usual fear of a new object. In avocado orchards rats can be trapped near or under woodpiles, near the trunks of trees where they have been feeding on the fruit, and, in fact, in practically any location. When placed on the ground, the trap may be countersunk in the soil with the trigger projecting above the surface. For especially wary rats, the traps may be covered with fine soil or sawdust, so long as the action of the trigger or spring is not adversely affected. Some rats will avoid exposed traps, but can be caught if the trap is shielded by a board or box, with space left for the rat to enter.

**Poisoning.** Poisoning has long been successfully practiced by avocado growers and is now coming into increasing favor because of the great success that has attended the use of the new poison Warfarin. One advantage of this poison is that it does not require prebaiting. Also it is not so poisonous to humans as some of the baits previously used.

Grains, such as oat groats, or any food eaten by humans may be used as bait. The poisoned bait in "bait boxes" is placed in locations that the rats are known to frequent. The bait boxes are left out several days and the poisoned bait is renewed until feeding ceases. Several days may be required to kill the rats.

Since the advent of Warfarin as a rat bait, many growers who formerly controlled rats by trapping are now resorting to poisoning. In some counties it is sold at cost by the county.

## OTHER RODENTS

Native wood rats, also known as "pack rats" or "trade rats," are also pests of the avocado. The species likely to be involved is the brown-footed wood rat, *Neotoma fuscipes* Baird, which inhabits the foothills and lower mountains. This species has a body 7 or 8 inches long and a tail 6.5 to 7.5 inches long. It has a blunt nose, slightly haired ears of medium size, brown fur, and moderately haired tail. This rat builds large, conical nests of sticks and litter on the ground or in trees and sometimes in buildings.

Wood rats will eat avocados, but a more serious damage results from their feeding on the bark, which sometimes results in the complete girdling and death of branches. They are not so wary as the alien rats and can readily be caught in spring rat traps baited with rolled oats, peanut butter, raisins, or prunes. Wood rats, as well as white-footed mice, should be handled in such a way as to avoid getting live fleas or ticks on the clothes or skin, for these may be carriers of disease. Gloves should be worn, and the clothing should be sprayed with pyrethrum spray immediately after these rodents are handled. The rodents should be burned outdoors, or buried to a depth of 2 feet.

The red fox squirrel, *Sciurus niger rufiventer* (Geoffroy), is an accidentally introduced species which now occurs in northern Los Angeles and Ventura counties. It feeds on walnuts, avocados, and oranges. It may be trapped with an extra large type of rat trap placed in trees.

Meadow mice or voles (*Microtus*) are injurious because they gnaw the bark and roots of avocado and citrus trees that are surrounded by grass and weeds. Their runways may be found in such locations. Mousetraps baited with oatmeal, rolled oats, or bits of apple or carrot may be set in these runways with the triggers of the traps *across* the runways. Mice running in either direction can then be trapped. When large numbers of mice are present, it may be advantageous to poison them. Strychnine on alfalfa leaves or rolled barley has been used, or zinc phosphide on rolled barley or oats.

Pocket gophers (*Thomomys* spp.) are destructive to young avocado trees, and their control demands continuous vigilance on the part of the grower. Their presence is indicated by a series of rounded surface mounds. They are controlled by trapping or poisoning.

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## AVOCADO PESTS DESCRIBED IN THIS CIRCULAR